(12) INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

(19) World Intellectual Property Organization
International Bureau

(43) International Publication Date
3 October 2002 (03.10.2002)

PCT

(10) International Publication Number
WO 02/078147 A1

(51) International Patent Classification[7]: H02J 3/24
// E02B 5/08

(21) International Application Number: PCT/SE02/00419

(22) International Filing Date: 8 March 2002 (08.03.2002)

(25) Filing Language: Swedish

(26) Publication Language: English

(30) Priority Data:
0101061-0 23 March 2001 (23.03.2001) SE

(71) Applicant *(for all designated States except US)*: **ABB AB** [SE/SE]; S-721 83 Västerås (SE).

(72) Inventors; and
(75) Inventors/Applicants *(for US only)*: **KARLSSON, Daniel** [SE/SE]; Vanåsgatan 5, S-216 20 Malmö (SE).

AKKE, Magnus [SE/SE]; Briggatan 16, S-234 42 Lomma (SE).

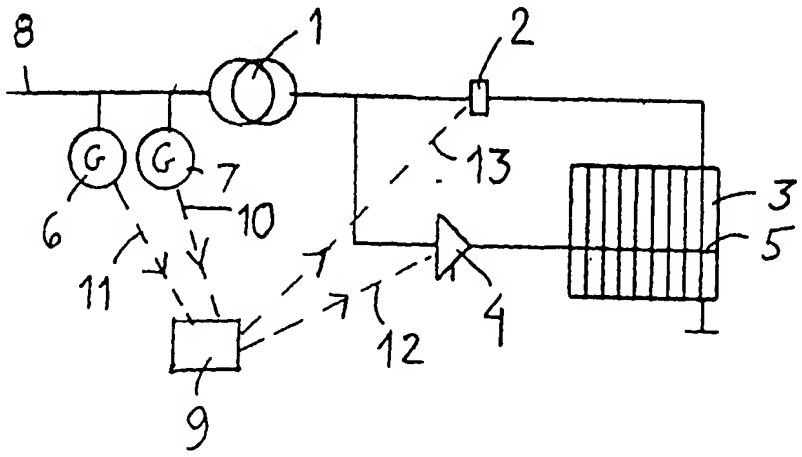
(74) Agent: **ABB GROUP SERVICES CENTER AB**; Legal & Compliance/Intellectual Property, Gideonsbergsgatan 2, S-721 78 Västerås (SE).

(81) Designated States *(national)*: AE, AG, AL, AM, AT, AT (utility model), AU, AZ, BA, BB, BG, BR, BY, BZ, CA, CH, CN, CO, CR, CU, CZ, CZ (utility model), DE, DE (utility model), DK, DK (utility model), DM, DZ, EC, EE, EE (utility model), ES, FI, FI (utility model), GB, GD, GE, GH, GM, HR, HU, ID, IL, IN, IS, JP, KE, KG, KP, KR, KZ, LC, LK, LR, LS, LT, LU, LV, MA, MD, MG, MK, MN, MW, MX, MZ, NO, NZ, PL, PT, RO, RU, SD, SE, SG, SI, SK, SK (utility model), SL, TJ, TM, TR, TT, TZ, UA, UG, US, UZ, VN, YU, ZA, ZW.

(84) Designated States *(regional)*: ARIPO patent (GH, GM, KE, LS, MW, MZ, SD, SL, SZ, TZ, UG, ZM, ZW), Eurasian patent (AM, AZ, BY, KG, KZ, MD, RU, TJ, TM), European patent (AT, BE, CH, CY, DE, DK, ES, FI, FR,

[Continued on next page]

(54) Title: POWER PLANT WITH MEANS FOR DAMPING POWER OSCILLATIONS



(57) Abstract: The invention relates to an electrical installation comprising at least one generator and at least one braking resistor. The braking resistor is adapted to damp power oscillations of the power system and/or to prevent out-of-phase situations. According to the invention, the braking resistor is in the form of a device arranged in the installation for a different purpose and suited for power consumption. The invention also relates to a microprocessor and a computer program product for use in such an installation. Further, the invention relates to a method for damping power oscillations in which, according to the invention, a device arranged in the installation for a different purpose, and suited for power consumption, is used as a braking resistor. The invention also relates to a method for rebuilding a power plant.

WO 02/078147 A1

GB, GR, IE, IT, LU, MC, NL, PT, SE, TR), OAPI patent (BF, BJ, CF, CG, CI, CM, GA, GN, GQ, GW, ML, MR, NE, SN, TD, TG).

For two-letter codes and other abbreviations, refer to the "Guidance Notes on Codes and Abbreviations" appearing at the beginning of each regular issue of the PCT Gazette.

Published:

— *with international search report*

Power plant with means for damping power oscillations

FIELD OF THE INVENTION

From a first aspect, the present invention relates to an electric power plant comprising at least one generator and at least one braking resistor adapted to damp power oscillations of the generator and/or to prevent out-of-phase situations.

From a second aspect, the invention relates to a microprocessor designed for use in such an electric plant.

From a third aspect, the invention relates to a computer program product for use in a microprocessor according to the second aspect of the invention.

From a fourth aspect, the invention relates to a method for damping power oscillations in an electric power plant comprising at least one generator and/or for preventing out-of-phase situations in such a plant, and in which method the power oscillations are damped with a braking resistor.

From a fifth aspect, the invention relates to a method for rebuilding an electric plant comprising at least one electric generator and a device suited for power consumption.

The electric power plant may be a hydroelectric generating station, a thermal-electric power plant, or some other electric power plant.

By a device suited for power consumption is meant in the present patent application, on the one hand, a device in which electric power is consumed for utilization for a definite purpose and where the installation is normally equipped with such a power-consuming device adapted for this particular purpose, for example an electrically-heated ice gate as described in the following, and, on the other hand, a device present in the installation for a specific purpose

and which is not normally power-consuming but which may be made connectible for power consumption, for example a simple intake screen at the inlet of a turbo installation or a cooling water installation.

BACKGROUND OF THE INVENTION

In the production of electric power in an electric power plant, out-of-phase situations and undesired power oscillations may arise in the power system of the plant, such as generators. Such power oscillations manifest themselves in that the rotor alternately rotates faster and slower than what corresponds to the frequency of the power system to which the generator is connected. The period of the oscillations varies substantially within the range 0.2 to 4 seconds. Oscillations with a growing amplitude usually lead to tripping of a relay protection device within some twenty or thirty seconds, or so, whereas undamped or slightly damped oscillations may remain for a longer period of time. The amplitude of the oscillations is usually a question of some twenty or thirty per cent, or so, of the load on a line or a generator. Power oscillations and out-of-phase situations may arise spontaneously or as a result of a fault and a disconnection in the power system to which the plant is connected.

It is desirable to ensure that such power oscillations and out-of-phase situations be damped/prevented. Various devices and measures, respectively, are previously known to attain this. Thus, it is previously known to provide the generators with damping windings. Further, it is known to use power system stabilizers (PSS) that usually feed back the power of the generator terminals to the voltage control on the machine. Further, it is previously known to achieve the damping by influencing the turbine control. However, the methods described have their disadvantages and limitations. The capacity in the voltage feeder often limits the power of the power system stabilizer, and the utilization of the turbine

control may be hazardous since this may lead to effects on the steam/water side that are difficult to handle.

Another previously known method is to utilize thyristor-switched braking resistors that are connected and disconnected in such a way that the power oscillations in the station are damped. This is an efficient method where the disadvantages of the previously known devices described above are eliminated. In addition, braking resistors are robust and may be applied not only at unit level but also at station level.

US 5,198,745 describes an example of power damping with the aid of a braking resistor. The document describes a dynamic braking system resistor to stabilize a power system during power system disturbances and comprises a braking system for connection to a line in the power system. A control unit senses a power-system parameter, such as the speed of a generator in the system, which is determining for the control signal to a thyristor. The control unit utilizes the power-system parameter to establish a desired modulation and exerts an influence in accordance with the desired modulation. The control unit processes the influenced desired modulation signal to produce the control signal to the thyristor. A thyristor valve connects the braking resistor in dependence on the control signal of the thyristor.

Although the utilization of braking resistors as dampers of power oscillations is efficient and appropriate, certain disadvantages are connected therewith. Above all, it is an expensive and space-demanding solution. A special component, the braking resistor, is added and the plant must be provided with connection means thereto.

In the light of what has been stated above, the object of the present invention is to bring about damping of power oscillations and/or to prevent out-of-phase situations while utilizing a braking resistor but where the above-mentioned

disadvantages with respect to high costs and bulky extra equipment are eliminated.

SUMMARY OF THE INVENTION

From the first aspect of the invention, the object set up is achieved in that an electric power plant of the kind described in the preamble to claim 1 exhibits the special feature that the braking resistor is in the form of a device which is also designed for a different purpose in the plant and which is suited for power consumption.

Thus, the term braking resistor in this context does not mean a dedicated device that is only used as a braking resistor, but a device that already exists in the plant for a different purpose and that may be used as a braking resistor. Because a device that already exists in the plant and that is suited for power consumption is utilized, damping with the aid of a braking resistor may be achieved without any extra cost for a special device of such a kind and without significant extra costs for its connection, especially when the device is of a kind that normally receives its electricity supply from the plant and thus is connected thereto.

Thus, a simple, robust and inexpensive braking resistor is achieved, which at the same time may be utilized, in a technically effective and appropriate way, for damping power oscillations or preventing out-of-phase situations.

According to a preferred embodiment of the invented power plant, the device suited for power consumption constitutes a common braking resistor for a plurality of generators in the plant. In this way, the possibility of applying the braking resistor at station level, instead of at unit level only, is made use of, which leads to a less expensive design in this respect.

According to another preferred embodiment, the device suited for power consumption is connected to the power system by

means of a first line provided with a switch and a second line, parallel to the first line, provided with a thyristor. This provides an effective possibility of controlling the connection of the device suited for power consumption in dependence on when it has to be utilized as a braking resistor.

According to a further preferred embodiment, thyristors are arranged, when the switch is open, to control the current supply to the device suited for power consumption. Hence, the power consumption of the braking resistor may be directly adapted to the power oscillations of the generator in an appropriate manner. To achieve the above-mentioned control, it is advantageous for the thyristor to be triac-connected. Therefore, this constitutes another preferred embodiment of the invention.

According to still another preferred embodiment of the invention, the plant comprises a microprocessor that is adapted to receive input signals indicative of power oscillations of the generator. Further, the microprocessor is adapted to deliver control signals to the thyristor in dependence on these input signals. The microprocessor has a program with an algorithm for this control.

Because the thyristor control is based on a programmed algorithm in this way, it is ensured that the power supply to the braking resistor is adequate in magnitude and timing such that the damping is optimally adapted to the need.

Suitably, the microprocessor is also adapted to provide control signals for opening and closing the switch. This, therefore, constitutes a further preferred embodiment of the invention.

According to yet another preferred embodiment of the invention, the device suited for power consumption is in the form of an intake gate or an ice gate. The intake gate or ice gate may, for example, be an electrically-heated ice gate of the

kind that normally occurs in hydroelectric plants, or a common intake screen that is normally not power-consuming but that may be provided with connection means enabling connection for power consumption. The utilization of an intake gate as a braking resistor has the advantage that this is a component that generally occurs in power plants and that is well suited as a braking resistor.

From the second aspect of the invention, the object set up is achieved in that a microprocessor is provided that is designed to be used in the invented electric plant. The microprocessor thus comprises a signal-receiving member adapted to receive input signals that are indicative of power oscillations of the power system. The microprocessor is adapted to deliver control signals to a thyristor and has a program with an algorithm for this control. The algorithm comprises instructions as to how the thyristor, in dependence on the input signals, delivers current to a device suited for power consumption.

The invented microprocessor makes it possible to implement the preferred embodiment of the invented plant which includes a microprocessor and which has been described above. Thus, the invented microprocessor entails the advantages that are associated with this embodiment of the plant.

From the third aspect of the invention, the object set up is achieved in that a computer program product for use in the invented microprocessor is provided. This results in the advantages that are associated with the utilization of such a microprocessor in a plant of the invented kind.

From a fourth aspect of the invention, the object set up is achieved in that a method of the kind described in the preamble to claim 11 comprises using a device, adapted for a different purpose in the plant and suited for power consumption, as a braking resistor.

By this method, advantages are achieved of a kind corresponding to those described above concerning the invented plant.

Preferred embodiments of the invented method comprise measures of a kind corresponding to what may be achieved with the preferred embodiments of the invented plant described above. The preferred embodiments of the invented method entail advantages of a kind corresponding to those described above concerning the preferred embodiments of the invented plant.

From the fifth aspect of the invention, the object set up is attained in that a method for rebuilding a power plant of the kind described in the preamble to claims 19 comprises connecting the device suited for power consumption to the power system close to the power station in such a way that the device suited for power consumption functions as a braking resistor for the generator. This method entails rebuilding the plant, using small means and limited efforts, such that it will have a design of the same kind as the invented plant. This results in advantages of a kind corresponding to those described above.

In preferred embodiments of the invented method for rebuilding, the method is carried out in such a way that the plant will have a design corresponding to that of any of the preferred embodiments of the invented power plant, thus gaining the advantages associated with these embodiments and described above.

The invention will be described in greater detail in connection with the following detailed description of advantageous embodiments of the invention and with reference to the accompanying figures.

BRIEF DESCRIPTION OF THE DRAWINGS

Figure 1 is a diagram of an embodiment of an electric plant according to the invention.

DESCRIPTION OF A PREFERRED EMBODIMENT OF THE INVENTION

Figure 1 shows a diagram for an electric power plant according to one embodiment of the invention. The shown plant may, for example, be a hydroelectric generating plant. The power system of the plant, in the form of generators 6, 7, is connected via a transformer 1 to an ice gate 3. An ice gate of this kind is normally connected to a generator in a hydroelectric generating plant, via a switch 2. The ice gate is heated by current from the generators 6, 7 and its power is typically about 1 % of the rated power of the plant. In accordance with the invention, a triac-connected thyristor 4 is connected in parallel with the switch 2. In the figure, the branch line with the thyristor 4 is connected to a cross iron 5 of the ice gate, but may alternatively be connected to its ordinary connection.

A microprocessor 9 is arranged in the plant. This is connected by means of the signalling circuit 10, 11 to each of the generators 6, 7 for receiving input signals therefrom. Further, the signalling circuits 12, 13 are arranged for connection of the microprocessor 9 to the thyristor 12 and the switch 2. The signalling circuits 12, 13 transmit control signals from the microprocessor to the thyristor 4 and to the switch 2. The microprocessor comprises a computer program with an algorithm that determines the control signals in dependence on the input signals.

Numeral 8 denotes the feeder from the plant. When a fault occurs somewhere in the power system to which the feeder delivers current, power oscillations and/or out-of-phase situations may arise in the generators 6, 7.

This manifests itself in the rotor of a generator starting to rotate at a varying speed.

These power oscillations of one or more of the generators 6, 7 are sensed and signals indicating these oscillations are transmitted to the microprocessor 9. When an oscillation arises, a signal from the microprocessor controls the switch 2 to open such that the current supply to the ice gate 3 instead occurs through the line provided with the thyristor 4. A second control signal from the microprocessor 9 controls the thyristor such that the power that is delivered to the ice gate 3 is controlled in dependence on the power oscillation in the generators 6, 7.

The ice gate 3 will thus function as a braking resistor and damp the power oscillations in the generators.

In another embodiment, the ice gate 3 has been replaced by an ordinary intake screen, provided with connection means for connection to the transformer 1 and the thyristor 4.

CLAIMS

1. An electric power plant comprising at least one generator (6, 7), a feeder (8) connected to the generator (6, 7) for supply of current, delivered by the generator (6, 7), to an electric power system, and at least one braking resistor (3) adapted to damp power oscillations of the generator and/or to prevent out-of-phase situations, **characterized** in that the braking resistor (3) consists of a device (3) adapted for a different purpose in the plant and suited for power consumption.

2. An electric power plant according to claim 1, **characterized** in that the device (3) suited for power consumption constitutes a common braking resistor for a plurality of generators (6, 7).

3. An electric power plant according to claim 1 or 2, **characterized** in that the device (3) suited for power consumption is connected to the power plant by means of a line provided with a thyristor (4).

4. An electric power plant according to claim 3, **characterized** in that the thyristor (4) is adapted to control the current supply to the device (3) suited for power consumption.

5. An electric power plant according to claim 4, **characterized** in that the thyristor (4) is triac-connected.

6. An electric power plant according to claim 4 or 5, **characterized** in that it comprises a microprocessor (9) adapted to receive signals that are indicative of power oscillations of the power system, and adapted to deliver control signals to the thyristor (4) in dependence on the input signals, said microprocessor (9) comprising a program with an algorithm for said control.

7. An electric power plant according to claim 6, **characterized** in that the microprocessor (9) is adapted also to control the opening and closing of a switch (2) connected in parallel with the thyristor (4).

8. An electric power plant according to any of claims 1-7, **characterized** in that the device (3) suited for power consumption is an intake or ice gate.

9. A microprocessor (9) for use in an electric power plant according to any of claims 1-8 and comprising a signal-receiving member adapted to receive signals that are indicative of power oscillations of the power system, and to deliver control signals adapted to control a thyristor (4), said microprocessor comprising a program with an algorithm for said control, **characterized** in that the algorithm comprises instructions as to how the thyristor (4), in dependence on the input signals, delivers current to a device that is suited for power consumption and that is of a kind in which the power is utilized.

10. A computer program product for use in a microprocessor according to claim 9 and comprising an algorithm adapted to process signals to deliver control signals in dependence on input signals, **characterized** in that the input signals consist of signals indicative of power oscillations of the power system and that the control signals consist of signals that control the current supply to a power-consuming device (3) arranged adjacent to the power plant.

11. A method for damping power oscillations in an electric power plant comprising at least one generator adapted for supply of current to an electric power system and/or for preventing out-of-phase situations in such a plant, in which method the power oscillations are damped with a braking resistor, **characterized** in that a device arranged for a different purpose in the plant and suited for power consumption is used as a braking resistor.

12. A method according to claim 11, **characterized** in that the device suited for power consumption is used as a common braking resistor for a plurality of generators.

13. A method according to claim 11 or 12, **characterized** in that the device suited for power consumption is connected to the generator by means of a line provided with a thyristor.

14. A method according to claim 13, **characterized** in that a switch connected in parallel with the thyristor is opened and that the thyristor, when the switch is open, controls the current supply to the device suited for power consumption.

15. A method according to claim 14, **characterized** in that the thyristor is triac-connected.

16. A method according to claim 14 or 15, **characterized** in that signals are delivered to a microprocessor which are indicative of power oscillations of the power system and that the microprocessor delivers control signals to the thyristor in dependence on the input signals.

17. A method according to claim 16, **characterized** in that the microprocessor also delivers control signals for opening and closing a switch connected in parallel with the thyristor.

18. A method according to any of claims 11-17, **characterized** in that the device suited for power consumption is an intake gate or an ice gate.

19. A method for rebuilding an electric power plant comprising at least one generator, adapted for supply of current to an electric power system, and a device suited for power consumption, **characterized** in that the device suited for power consumption is connected to the power plant in such a way that the device suited for power consumption functions as a braking resistor for the generator.

20. A method according to claim 19, **characterized** in that the electric power plant is rebuilt such that an electric power plant according to any of claims 2-8 is obtained.

1/1

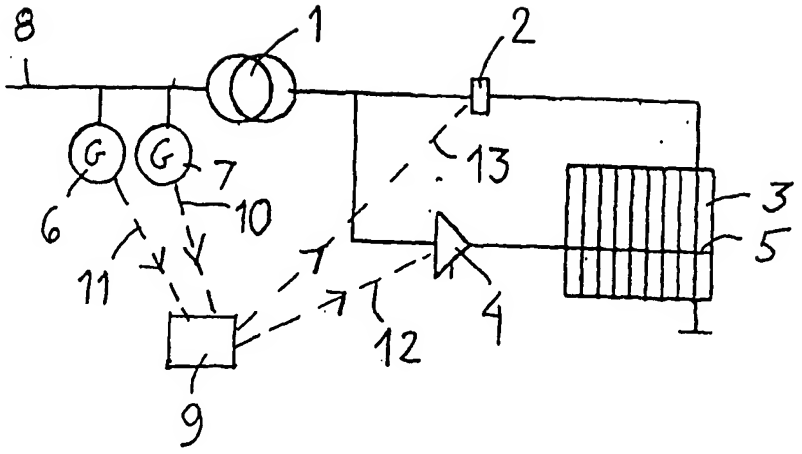


Fig.1

INTERNATIONAL SEARCH REPORT

International application No.
PCT/SE 02/00419

A. CLASSIFICATION OF SUBJECT MATTER

IPC7: H02J 3/24 // E02B 5/08
According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

IPC7: H01J, H02P, E02B

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

SE,DK,FI,NO classes as above

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

EPO-INTERNAL, WPI DATA, PAJ, INSPEC

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A,D	US 5198745 A (EINAR V. LARSEN ET AL), 30 March 1993 (30.03.93), abstract ---	1-20
A	WO 9950945 A1 (MITA-TEKNIK A/S), 7 October 1999 (07.10.99), abstract --- --------	1-20

☐ Further documents are listed in the continuation of Box C. ☒ See patent family annex.

* Special categories of cited documents:
"A" document defining the general state of the art which is not considered to be of particular relevance
"E" earlier application or patent but published on or after the international filing date
"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)
"O" document referring to an oral disclosure, use, exhibition or other means
"P" document published prior to the international filing date but later than the priority date claimed
"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention
"X" document of particular relevance: the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone
"Y" document of particular relevance: the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art
"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
17 June 2002	01-07-2002
Name and mailing address of the ISA/ Swedish Patent Office Box 5055, S-102 42 STOCKHOLM Facsimile No. +46 8 666 02 86	Authorized officer Tomas Erlandsson/MN Telephone No. +46 8 782 25 00

Form PCT/ISA/210 (second sheet) (July 1998)

INTERNATIONAL SEARCH REPORT

International application No.
PCT/SE 02/00419

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
US 5198745 A	30/03/93	AU 643931 B	25/11/93
		AU 2249292 A	02/03/93
		EP 0557471 A	01/09/93
		WO 9303531 A	18/02/93
WO 9950945 A1	07/10/99	AU 3025799 A	18/10/99
		DK 43899 A	01/10/99
		EP 1097499 A	09/05/01
		JP 2002510951 T	09/04/02
		NO 20004889 A	29/09/00